Aquatic Invasions (2007) Volume 2, Issue 1: 39-44
DOI 10.3391/ai.2007.2.1.4

Research article

Distribution and abundance of Ponto-Caspian amphipods in the Belarusian section of the Dnieper River

Sergey E. Mastitsky[1*] and Oleg A. Makarevich[2]
[1]*General Ecology Department, Biology Faculty, Belarusian State University, Belarus*
[2]*Research Laboratory of Aquatic Ecology, Belarusian State University, Belarus*
[*]*Corresponding author*
E-mail: sergmast@tut.by

Received 11 January 2007; accepted in revised form 15 February 2007

Abstract

During a survey of the Belarusian part of the Dnieper River conducted on 19-22 July 2006, we revealed five invasive Ponto-Caspian amphipod species in its benthos community: *Chaetogammarus ischnus*, *Chelicorophium curvispinum*, *Dikerogammarus haemobaphes*, *Dikerogammarus villosus* and *Pontogammarus robustoides*. All of them except *C. curvispinum* are reported in Belarus for the first time. The number of alien amphipod species and their abundance were found to decrease gradually in the upper sections of the river.

Key words: Belarus, central invasion corridor, Dnieper, *Chelicorophium curvispinum*, *Dikerogammarus haemobaphes*, *Dikerogammarus villosus*, *Chaetogammarus ischnus*, *Pontogammarus robustoides*

Introduction

The Republic of Belarus contains a considerable part of the so called central invasion corridor (Bij de Vaate et al. 2002), i.e. the Dnieper River with its large tributaries Pripyat, Berezina and Sozh (Figure 1). This means that the waterways of this country have and are likely to still play an important role in the process of Ponto-Caspian aquatic species spread to Central and Western Europe, in particular to the neighboring territories of Poland and Lithuania. However, until now Belarus remained a 'white spot' on European distribution maps of these species. The reasons for this situation are diverse, but firstly they include the absence of a national strategy in the field of biological invasions, poor financing of corresponding scientific studies and a critical lack of taxonomical specialists in major groups of aquatic invertebrates (First national report… 1998). As a result, so far only the most annoying, high impact invasive species were revealed and investigated satisfactorily, for example, the zebra mussel, *Dreissena polymorpha* (Pallas, 1771) (Karatayev 1983, Burlakova 1998, Karatayev et al. 2000, 2002; Mastitsky 2004). Information on other species is highly dispersed among different sources (both literature and verbal), most of which are not readily accessible, especially for non-Russian scientists. At the same time, easy access to such information could become crucial for further understanding of both vectors and routes of aquatic invasions throughout Europe. To address this problem, since 2005 we are developing an online database 'Aquatic invaders of Belarus', which is to be launched in the early 2007. This work consists of two main parts: i) classification of all available literature on invaders and ii) execution of field surveys aimed at both verifying old records and detecting new species and their localities. The present paper is directly related to development of the database and is based on benthic sampling conducted from 19-22 July 2006 during an expedition along the Belarusian section of the Dnieper River (720 km, i.e. about 32% of the total length). We report some preliminary results of this survey, namely data on species composition, abundance and distribution of invasive crustaceans from the order Amphipoda.

Material and Methods

The samples were collected near the bank from a depth of 0.3-0.8 m at five stations distributed approximately uniformly along the river (Figure 1). Description of general physical and biotic conditions at each station is given in Annex 1.

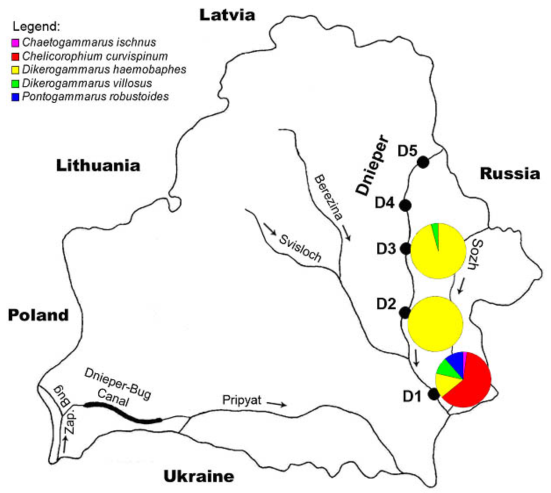

Figure 1. Belarusian section of the Dnieper River and its main tributaries (modified from Karatayev et al. 2000). D1-D5 are stations sampled in this study. Pie-charts characterise composition of alien gammarid communities as % total number of individuals sampled

Quantitative samples with three replicates were taken at stations D1 and D3 with an Eckman-type sampler (capture area 104 cm^2) installed on a 1.5 m long pole. Qualitative collections of macroinvertebrates were performed with a hand net (mesh size 1 mm) and via visual examination of stones, snags and other hard substrates (30-minute effort by two people) at two latter stations and at all other visited sites. Macroinvertebrate samples were preserved in 4% formaldehyde for subsequent taxonomical identification. Alien amphipods were identified according to Konopacka (2004).

Results and Discussion

We revealed five amphipod species originating from the Ponto-Caspian region: *Chaetogammarus ischnus* (Stebbing, 1899), *Chelicorophium curvispinum* (G.O. Sars, 1895), *Dikerogammarus haemobaphes* (Eichwald, 1841), *Dikerogammarus villosus* (Sowinsky, 1894) and *Pontogammarus robustoides* (G.O. Sars, 1894) (Figure 2, Annex 2). Most of them are likely to arrive in Belarusian waters through the shipping canal between the Pripyat River, a tributary of the Dnieper River (Black Sea basin), and the Zapadnyi Bug River (Baltic Sea basin) (reviewed in Bij de Vaate et al. 2002, Jazdzewski and Konopacka 2002), which was constructed about 200 years ago and is still navigable within the territory of Belarus. However, these species did not arrive synchronously. For example, *C. curvispinum* may be considered as the oldest crustacean invader in Belarus because it was first recorded in the Pripyat River in 1914 (Wolski 1930). Later, *C. curvispinum* was found also in the Dnieper River (Vladimirova et al. 1965) and Berezina River (Tischikov and Tischikov 1999). *C. ischnus* was never recorded in Belarus before our study; however, its record in the Polish River Vistula in 1928 (reviewed in Jazdzewski and Konopacka 2002, Grabowski et al. 2006, 2007) indicates that it is likely as old an invader as *C. curvispinum*. The absence of previous findings of *C. ischnus* in Belarusian waters may be explained by its typically low abundance in invasive amphipod communities (Haas et al. 2002, Jazdzewski and Konopacka 2002, Grabowski et al. 2007, see also Figure 1). The shrimps *D. haemobaphes* and *D. villosus* are the most recent newcomers. This statement is validated by the fact that *D. haemobaphes* was detected only very recently (1997) in the protractedly monitored Polish River Vistula (Konopacka 1998). *Dikerogammarus villosus* was found for the first time outside its native range only in 1992, i.e. in the upper reaches of the Danube River, and two years later was discovered in the lower reaches of the Rhine River (reviewed in Bij de Vaate et al. 2002). Until now, *D. villosus* has been colonising

Europe through the 'southern invasion corridor' (Bij de Vaate et al. 2002); however, the presence of this species in the Dnieper River in Belarus and in the Zapadnyi Bug in Poland (Konopacka 2004, Grabowski et al. 2007) indicates that it has also begun to spread through the 'central corridor'.

It is not clear when and how Belarus was invaded by the remaining species, *Pontogammarus robustoides*, but a hypothesis can be made that it came in the second part of the 20th century because the species was not previously recorded in any part of that country. There are two possible ways that *P. robustoides* arrived in Belarus. Since its native range includes the lower courses of the Dnieper River, *P. robustoides* might have colonised at least part of the Europe through the Dnieper-Bug Canal, and results of our study are consistent with this assumption. On the other hand, this species was repeatedly intentionally introduced into reservoirs and lakes in Lithuania (reviewed in Arbačiauskas 2005). In several of these waterbodies *P. robustoides* has established stable populations that could be the secondary sources for invasion across European countries, including Belarus. Similar route of *P. robustoides* invasion from Lithuania into Poland is suggested by Grabowski et al. (2007).

Both the distribution and abundance of invasive amphipods in the Dnieper River have demonstrated a clear pattern. The maximum number of species was observed at the downstream station D1 (Figure 1). In terms of the density and biomass, the most abundant species sampled there were *C. curvispinum* and *D. villosus* (Annex 2). A similar dominance of these two species in invasive amphipod communities has been reported in several other European rivers, e.g. Meuse (Josens et al. 2005), Oder (reviewed in Jazdzewski and Konopacka 2002), and Rhine (Bij de Vaate et al. 2002, Bernauer and Jansen 2006, Van Riel et al. 2006b). High densities of *C. curvispinum* and *D. villosus* may be accompanied with numerous ecological consequences. For example, *C. curvispinum* is known to build mud tubes on stony substrates, often resulting in three dimensional changes in bottom relief (so called 'corophiid grounds') (Lubyanov et al. 1967, Haas et al. 2002). This, in turn, creates inter-tube spaces particularly suitable for the development of communities composed of gammarids (including *D. haemobaphes* and *D. villosus*), oligochaetes, leeches, molluscs, and chironomids (Lubyanov et al. 1967). Mud tubes of *C. curvispinum*,

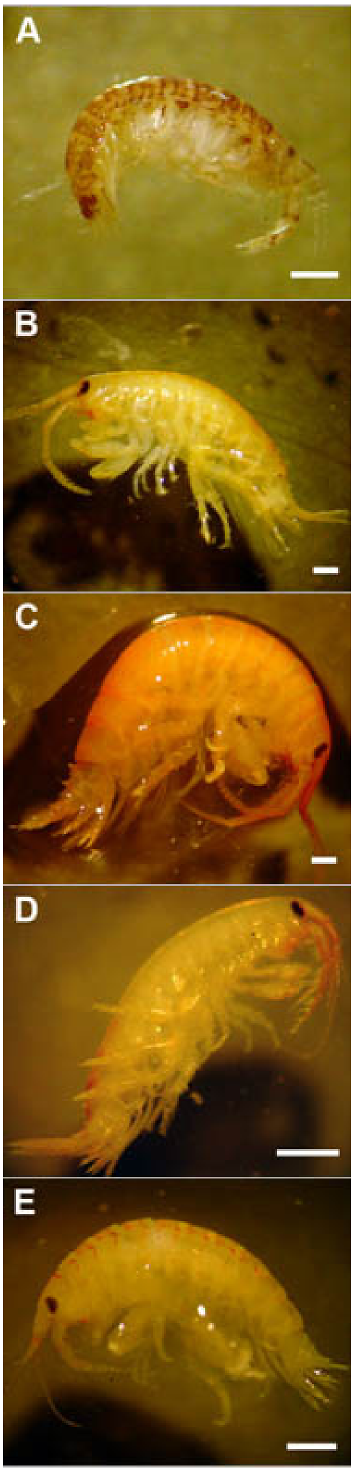

Figure 2. Ponto-Caspian amphipods found in the Belarusian section of the Dnieper River in July 2006. A: *Chelicorophium curvispinum*; B: *Dikerogammarus haemobaphes*; C: *Dikerogammarus villosus*; D: *Chaetogammarus ischnus*; E: *Pontogammarus robustoides*. Scale bar is 1 mm. (Photo by Sergey Mastitsky)

however, may negatively affect another lithophylic species, *Dreissena polymorpha* (zebra mussel), by inhibiting successful larval settlement (Van den Brink et al. 1991, Van der Velde et al. 1998, Haas et al. 2002). Indeed, we observed very low densities of *D. polymorpha* at station D1 (authors, unpublished), even though the sandy-stony bottom there (Annex 1) presented a very suitable substrate for this mussel.

Chelicorophium curvispinum is an active filter feeder, which especially benefits from high concentrations of phytoplankton in large rivers (Van der Velde et al. 1998). At the same time, it can serve as a prey item for several other invasive species, e.g. fish (Grabowska and Grabowski 2005) and gammarids (Van Riel et al. 2006a), thus participating in 'invasional meltdown' (Simberloff and Von Holle 1999).

Dikerogammarus villosus, which had the highest biomass at station D1 (Annex 2), is known to be one of the most aggressive amphipod invaders. Many researchers have observed rapid partial to complete displacement of native and naturalised invasive amphipods and isopods after arrival of this species (Haas et al. 2002, Van der Velde et al. 2000, Josens et al. 2005, MacNeil and Platvoet 2005, Bernauer and Jansen 2006, Van Riel et al. 2006a,b). Such distinctive invasiveness of *D. villosus* may be related to several ecological traits, including its: i) broad salinity and temperature tolerances (Muskó 1992, Bij de Vaate and Klink 1995), ii) top predator position in the food webs (Van Riel 2006a), iii) success in intra-guild predation (Dick and Platvoet 2000, Haas et al. 2002, MacNeil and Platvoet 2005), iv) ability to colonise a wide range of substrata (Dedju 1967, Devin et al. 2003) and to exploit available food resources more efficiently than native gammarids (Josens et al. 2005, Platvoet et al. 2006). As a consequence, the speed of active *D. villosus* upstream range extension may reach up to 40 km/year, i.e. ca. 100 m/day (Josens et al. 2005).

Despite the presence of suitable substrates in upper sections of the Dnieper River (Annex 1), the number of species and their abundance gradually declined, with no amphipods found at points D4 and D5 (Annex 2, Figure 1). The reasons for such distribution are not clear, especially taking into account that *C. curvispinum* and *C. ishnus*, which are the oldest amphipod invaders in Belarus (see above), have had enough time to reach upper sections of the river. According to Josens et al. (2005), upstream migration speed of *C. curvispinum* may be as high as 17 km/year. However, we predict that pattern of distribution of Ponto-Caspian amphipods in the Dnieper River within Belarus will change in the near future because of range extension of recently arrived *D. villosus* and *D. haemobaphes*. Already now, they are the most upstream distributed alien amphipods (Figure 1, Annex 2), which can be related to their pronounced invasiveness (Haas et al. 2002, Van der Velde et al. 2000, Bij de Vaate et al. 2002, Jazdzewski and Konopacka 2002, Josens et al. 2005, MacNeil and Platvoet 2005, Bernauer and Jansen 2006, Van Riel et al. 2006a,b).

Acknowledgements

This work was partly supported by the European Commission 6th Framework Program Integrated Project ALARM (contract GOCE-CT-2003-506675). We are grateful to Yuriy N. Kondobarov for his help both driving and sampling for this research survey. Drs. Alexander Y. Karatayev and Lyubov E. Burlakova (Stephen F. Austin State University, TX, USA) are acknowledged for giving us an access to their personal bibliographic database on zoobenthos of Belarusian waterbodies. We also thank Drs. Frances Lucy (Institute of Technology, Sligo, Ireland) and Daniel P. Molloy (New York State Museum, USA) for correction of English of the manuscript. Comments and suggestions of anonymous reviewer helped us to improve the narrative.

References

Arbačiauskas K (2005) The distribution and local dispersal of Ponto-Caspian Pericarida in Lithuanian fresh waters with notes on *Pontogammarus robustoides* population establishment, abundance and impact. Oceanological and Hydrobiological Studies XXXIV(1): 93-111

Bernauer D and Jansen W (2006) Recent invasions of alien macroinvertebrates and loss of native species in the upper Rhine River, Germany. Aquatic Invasions 1(2): 55-71

Bij de Vaate A and Klink A (1995) *Dikerogammarus villosus* Sowinsky (Crustacea: Gammaridae) a new immigrant in the Dutch part of the lower Rhine. Lauterbornia 20: 51-54

Bij de Vaate A, Jazdzewski K, Ketelaars HAM, Gollasch S and Van der Velde G (2002) Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe. Canadian Journal of Fisheries and Aquatic Sciences 59:1159-1174

Burlakova LE (1998) Ecology of *Dreissena polymorpha* (Pallas) and its role in the structure and functioning of aquatic ecosystems. PhD Thesis, Zoology Institute of the National Academy of Sciences of the Republic of Belarus, Minsk

Dedju II (1967) Amphipods and mysids of basins of the rivers Dniester and Prut. Nauka Press, Moscow

Devin S, Piscart C, Beisel JN and Moreteau JC (2003) Ecological traits of the amphipod invader *Dikerogammarus villosus* on the mesohabitat scale. Archiv für Hydrobiologie 158:43–56

Dick JTA and Platvoet D (2000) Invading predatory crustacean *Dikerogammarus villosus* eliminates both native and exotic species. Proceedings of the Royal Society, Series B: Biological Sciences 267: 977–983

First national report on implementation of Convention on biological diversity in Belarus (1998). Pikulik MM (ed). Belsens Press, Minsk

Grabowska J and Grabowski M (2005) Diel-feeding activity in early summer of racer goby *Neogobius gymnotrachelus* (Gobiidae): a new invader in the Baltic basin. Journal of Applied Ichthyology 21: 282-286

Grabowski M, Konopacka A, Jazdzewski K and Janowska E (2006) Invasions of alien gammarid species and retreat of natives in the Vistula Lagoon (Baltic Sea, Poland). Helgoland Marine Research (2006) 60: 90–97

Grabowski M, Jazdzewski K and Konopacka A (2007) Alien Crustacea in Polish waters – Amphipoda. Aquatic Invasions 2(1): 25-38

Haas G, Brunke M, Strei B (2002) Fast turnover in dominance of exotic species in the Rhine River determines biodiversity and ecosystem function: an affair between amphipods and mussels. In: Leppäkoski E, Gollasch S and Olenin S (eds) Invasive aquatic species of Europe: Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 426-432

Jazdzewski K and Konopacka A (2002) Invasive Ponto-Caspian species in waters of the Vistula and Oder basins and the southern Baltic Sea. In: Leppäkoski E, Gollasch S and Olenin S (eds) Invasive aquatic species of Europe: Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 384-398

Josens G, Bij de Vaate A, Usseglio-Polatera P, Cammaerts R, Chérot F, Grisez F, Verboonen P and Bossche J-PV (2005) Native and exotic Amphipoda and other Pericarida in the River Meuse: new assemblages emerge from a fast changing fauna. Hydrobiologia 542: 203-220

Karatayev AY (1983) Ecology of *Dreissena polymorpha* Pallas and its effects on macrozoobenthos of the thermal power plant's cooling reservoir. PhD Thesis, Zoology Institute of the Academy of Sciences of Belarusian SSR, Minsk

Karatayev AY, Burlakova LE, Molloy DP and Volkova LK (2000) Endosymbionts of *Dreissena polymorpha* (Pallas) in Belarus. International Review of Hydrobiology 85: 543-559

Karatayev AY, Burlakova LE and Padilla DK (2002) Impacts of zebra mussels on aquatic communities and their role as ecosystem engineers. In: Leppäkoski E, Gollasch S and Olenin S (eds) Invasive aquatic species of Europe: Distribution, impacts and management. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 433-446

Konopacka A (1998) *Dikerogammarus haemobaphes* (Eichwald, 1841) (Crustacea, Amphipoda), a new species in Polish fauna and two other rare amphipods in the Vistula River. Przeglad Zoologiczny 42(3-4): 211-218

Konopacka A (2004) Invasive amphipods (Crustacea, Amphipoda) in Polish waters. Przeglad Zoologiczny 48(3-4): 141-162

Lubyanov IP, Buzakova AM, Gaydash YK (1967) Changes in composition of macro- and microzoobenthos of the Dneprovskoe Reservoir after establishment of regulated run-off in the middle course of the Dnieper River. In: Vladimirova KS, Zerov KK, Melnichuk GL, Olivari GA and Tseeb YY (eds) Hydrobiological regime of the Dnieper River under conditions of regulated run-off. Naukova Dumka Press, Kiev, pp 167-175

MacNeil C and Platvoet D (2005) The predatory impact of the freshwater invader *Dikerogammarus villosus* on native *Gammarus pulex* (Crustacea: Amphipoda); influences of differential microdistribution and food resources. Journal of Zoology (London) 267: 31-38

Mastitsky SE (2004) Endosymbionts of bivalve mollusc *Dreissena polymorpha* (Pallas) in waterbodies of Belarus. PhD Thesis, Zoology Institute of the National Academy of Sciences of the Republic of Belarus, Minsk [in Russian]

Muskó IB (1992) Amphipoda species found in Lake Balaton since 1987. Miscnea. Zoology Hungary 7: 59-64

Platvoet D, Dick JTA, Konijnendijk N and Van der Velde G (2006) Feeding on micro-algae in the invasive Ponto-Caspian amphipod *Dikerogammarus villosus* (Sowinsky, 1894). Aquatic Ecology 40(2): 237-245

Simberloff D and Von Holle B (1999) Positive interactions of nonindigenous species: invasional meltdown? Biological Invasions 1: 21-32

Tischikov GM and Tischikov IG (1999) Macrozoobenthos fauna in the middle and low Berezina River. In: Karatayev AY (ed) Proceedings of the International conference on aquatic ecosystems ‘The results and future of aquatic ecology research’. Belarusian State University Press, Minsk, pp 251-264

Van den Brink FWB, Van der Velde G and Bij de Vaate A (1991) Amphipod invasion on the Rhine. Nature 352: 576

Van der Velde G, Rajagopal S, Van den Brink FWB, Kelleher B, Paffen BGP, Kempers AJ and Bij de Vaate A (1998) Ecological impact of an exotic invasion in the River Rhine. In: Nienhuis PH, RSEW Leuven and Ragas AMJ (eds) New concepts for sustainable management of river basins. Backhuys Publishing, Leiden, pp 159–169

Van Riel MC, Van der Velde G, Rajagopal S, Marguillier S, Dehairs F and Bij de Vaate A (2006a) Trophic relationships in the Rhine food web during invasion and after establishment of the Ponto-Caspian invader *Dikerogammarus villosus*. Hydrobiologia 565: 39-58

Van Riel MC, Van der Velde G and Bij de Vaate A (2006b) To conquer and persist: colonization and population development of the Ponto-Caspian amphipods *Dikerogammarus villosus* and *Chelicorophium curvispinum* on bare stone substrate in the main channel of the River Rhine. Archiv für Hydrobiologie 166(1): 23-39

Vladimirova KS, Gurvich VV and Olivari GA (1965) Benthos of the upper course of the Dnieper and waterbodies of its floodplain (within Belarusian SSR). In: Bulavko AG, Zakharenkov IS, Ostapenya AP and Prokudin FD (eds) Proceedings of Republican scientific-technical workshop on studies, complex use and conservation of water resources. Minsk, pp 16-21

Wolski T (1930) *Corophium curvispinum* G. O. Sars in der Prypeć und in den Warschauer Wasserleitungsanlagen. Fragmenta faunistica musei zoologici Polonici 1(6):152-159

Annex 1
Stations on the Dnieper River sampled during the study

Station	Date	Closest human settlement	Station coordinates		Approx. river width, m	Substrates, macrophytes and other relevant information	Presence of alien amphipods
			Latitude, °N	Longitude, °E			
D1	19.07.2006	Kholmech, village	52°09.26′	30°38.18′	150	Sandy-stony substrate. Rare beds of *Potamogeton* spp., Unionidae and Viviparidae molluscs common with occasional zebra mussels.	+
D2	21.07.2006	Rogachev, town	53°07.14′	30°04.92′	30	Pure fine-grained sand with patches of silted sand. Rare wood snags.	+
D3	21.07.2006	Staiki, village	53°43.39′	30°17.23′	30	Spit of coarse-grained sand with clay substrate around it. Sporadic macrophytes.	+
D4	21.07.2006	Litovsk, village	54°09.38′	30°20.54′	50	Stony substrate. Beds of macrophytes (*Potamogeton* spp. dominant). Cold underwater springs in this area.	-
D5	22.07.2006	Dubrovno, town	54°33.67′	30°37.25′	30	Stony substrate. Beds of macrophytes (*Sagittaria sagittifolia*, *Nuphar* sp., *Potamogeton* spp. and *Equisetum* spp.).	-

Annex 2
Species composition and abundance of Ponto-Caspian gammarids in the Dnieper River, Belarus, July 2006

Station	Species	Range of density (indiv./m^2)	Range of biomass (g/m^2)	% range of total macroinvertebrat e biomass *
D1	*Chaetogammarus ischnus* (Stebbing, 1899)	n. r. **	n. r.	n. r.
	Chelicorophium curvispinum (G.O. Sars, 1895)	2596 – 4615	1.7 – 4.2	8.1 – 40.1
	Dikerogammarus haemobaphes (Eichwald, 1841)	0 – 577	0 – 0.2	0 – 1.1
	Dikerogammarus villosus (Sowinsky, 1894)	0 – 481	0 - 14	0 – 66.1
	Pontogammarus robustoides (G.O. Sars, 1894)	192 – 481	0.1 – 1.6	0.7 – 17.3
D2	*Dikerogammarus haemobaphes* (Eichwald, 1841)	n. r.	n. r.	n. r.
D3	*Dikerogammarus haemobaphes* (Eichwald, 1841)	n. r.	n. r.	n. r.
	Dikerogammarus villosus (Sowinsky, 1894)	n. r.	n. r.	n. r.

* - excluding molluscs
** - not recorded as species was found only in qualitative samples